United States Patent [19]

Trent

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[54] **POWER VENT AND CONTROL FOR FURNACE**

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[73] Assignee: **Heil Quaker Corporation,** Lavergne, Tenn.

[21] Appl. No.: **588,723**

[22] Filed: **Mar. 12, 1984**

Related U.S. Application Data

[63] Continuation of Ser. No. 338,664, Jan. 11, 1982, Pat. No. 4,460,329, which is a continuation-in-part of Ser. No. 116,021, Jan. 23, 1980, abandoned.

[51] **Int. Cl.[4]** **F23N 3/00**

[52] **U.S. Cl.** .... **431/20;** 431/31; 126/116 A

[58] **Field of Search** .... 431/20, 31; 126/110 R, 126/110 C, 110 E, 116 A

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,713,442	5/1929	Matcovich .	
1,892,188	12/1932	Goodridge .	
2,169,077	8/1939	Turner .	
2,174,710	10/1939	Wagner	236/44
2,217,518	10/1940	Merk	431/20
2,225,237	12/1940	Shaw .	
2,246,566	6/1941	Ames et al.	431/20
3,245,456	4/1966	Cox	431/31
3,277,947	10/1966	Gacioch .	
3,280,774	10/1966	English	110/162
3,403,962	10/1968	Suffron et al.	431/20
3,589,846	6/1971	Place et al.	431/31
3,650,262	3/1972	Root et al.	431/20
4,003,046	1/1977	Jordan	340/271
4,090,181	5/1978	Ansari et al.	340/271
4,251,025	2/1981	Bonne et al.	236/14
4,340,355	7/1982	Nelson et al.	431/20

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Attorney, Agent, or Firm—Jeffers, Hoffman & Niewyk

[57] **ABSTRACT**

An improved power vent and associated control system for a heating apparatus such as a furnace. The invention utilizes a vent blower and a flow control orifice device permitting the use of a single size air moving device and motor with different size furnaces. The control is arranged to discontinue delivery of fuel to the furnace in the event of a blockage of the furnace flue or a failure of the air moving structure. In one form of the invention, a pressure condition is sensed downstream of the air moving structure to detect the failure conditions. In another form of the invention, the control utilizes structure to sense the speed of the air moving device. The invention comprehends the use of a motor for driving the air moving device which varies in speed substantially between the unloaded and loaded conditions. The air moving device preferably unloads under high discharge pressure conditions, such as by a blocked flue. In a preferred form of the invention, a closure closes the orifice during periods when the vent blower is not operating. The closure is responsive to fluid movement through the orifice to move automatically to an open condition.

14 Claims, 4 Drawing Sheets

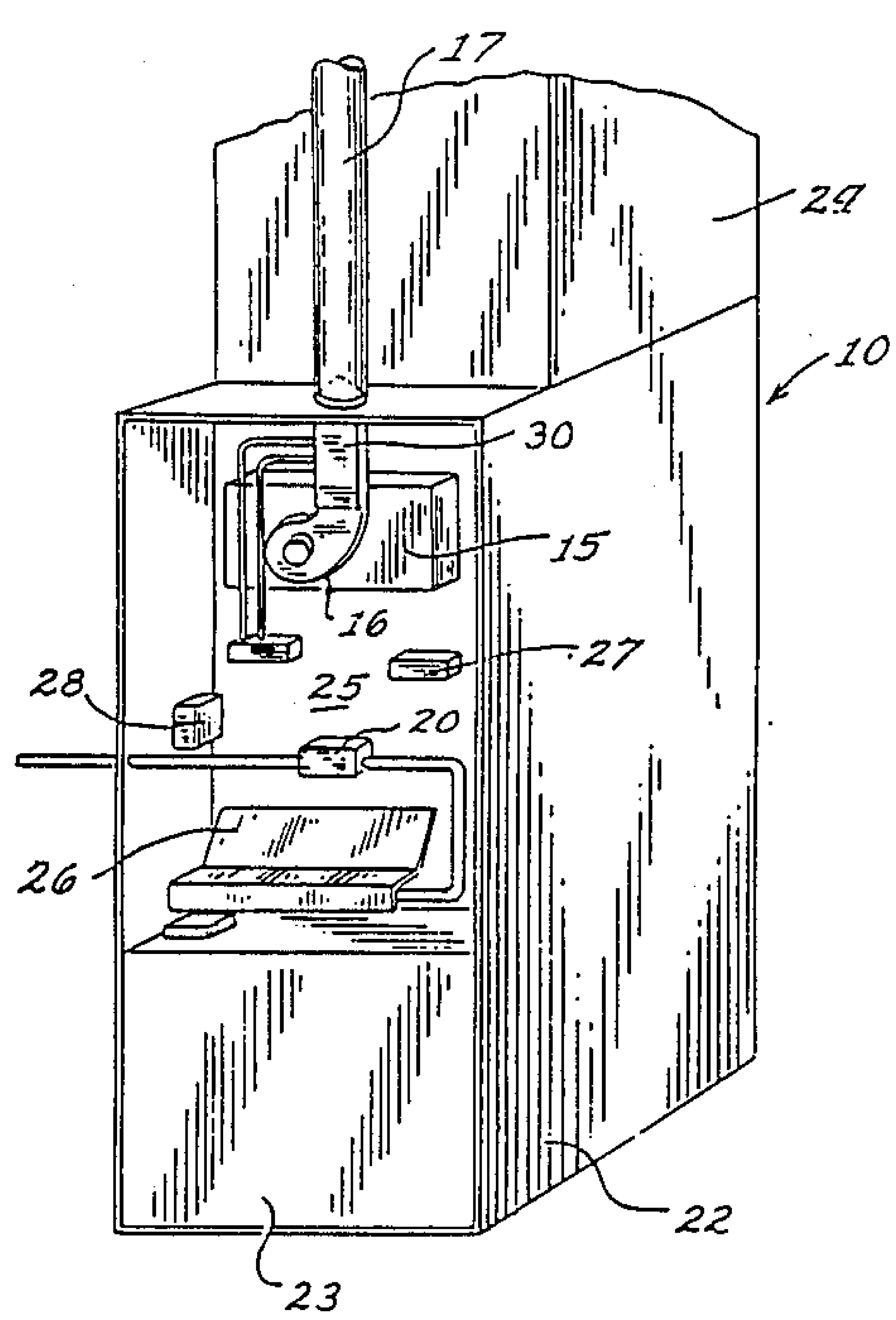


Fig. 1.

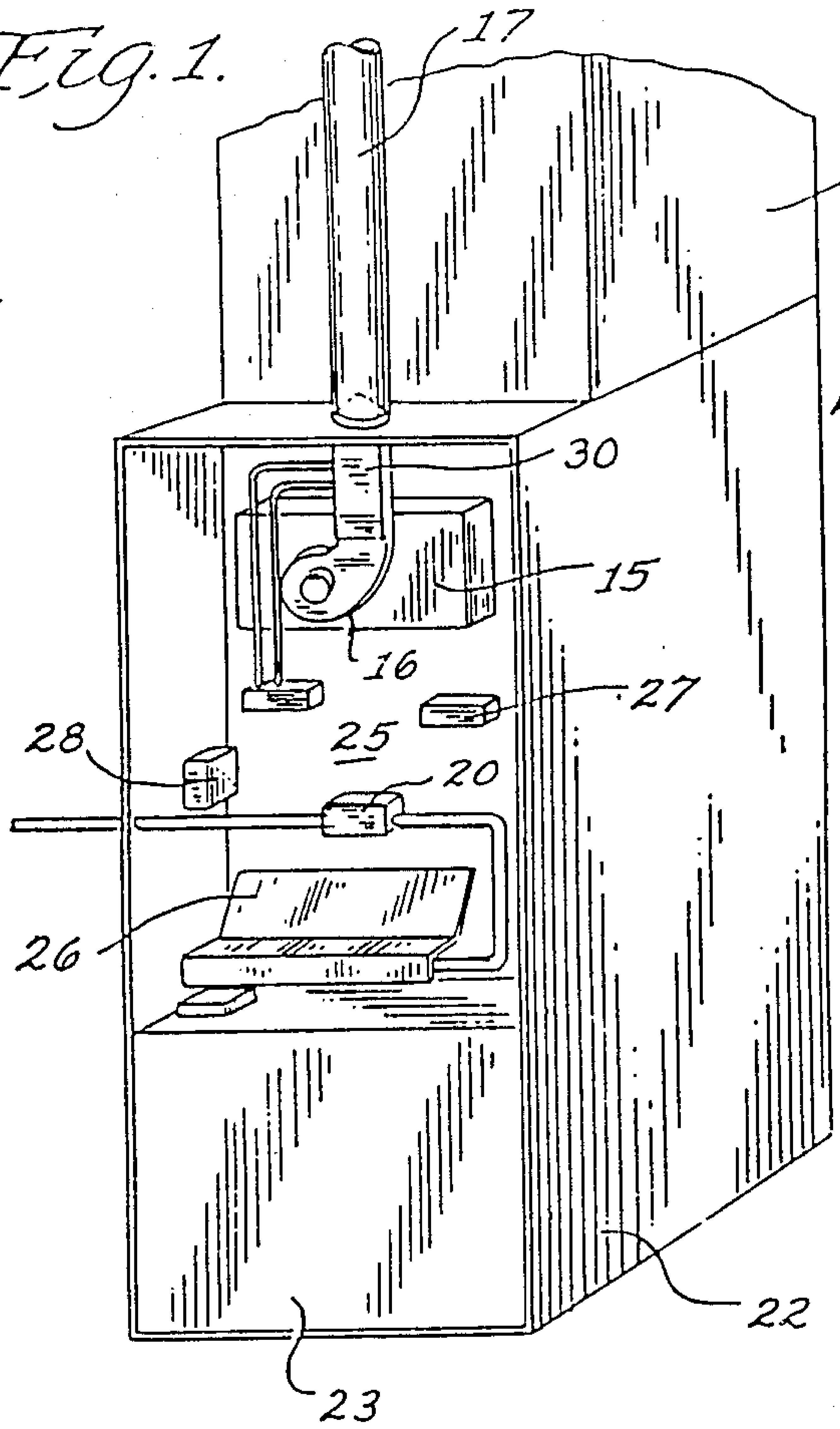
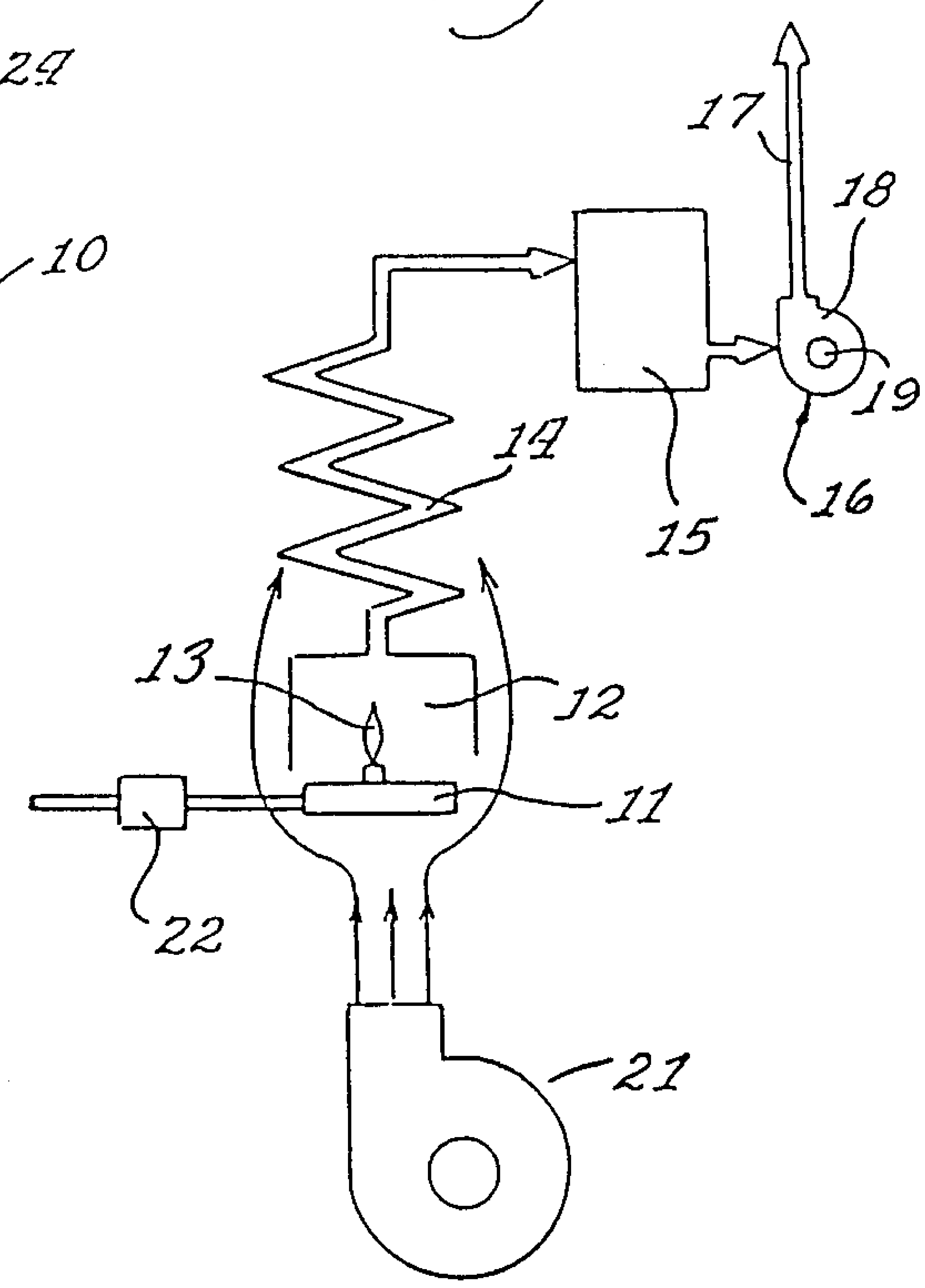


Fig. 2.



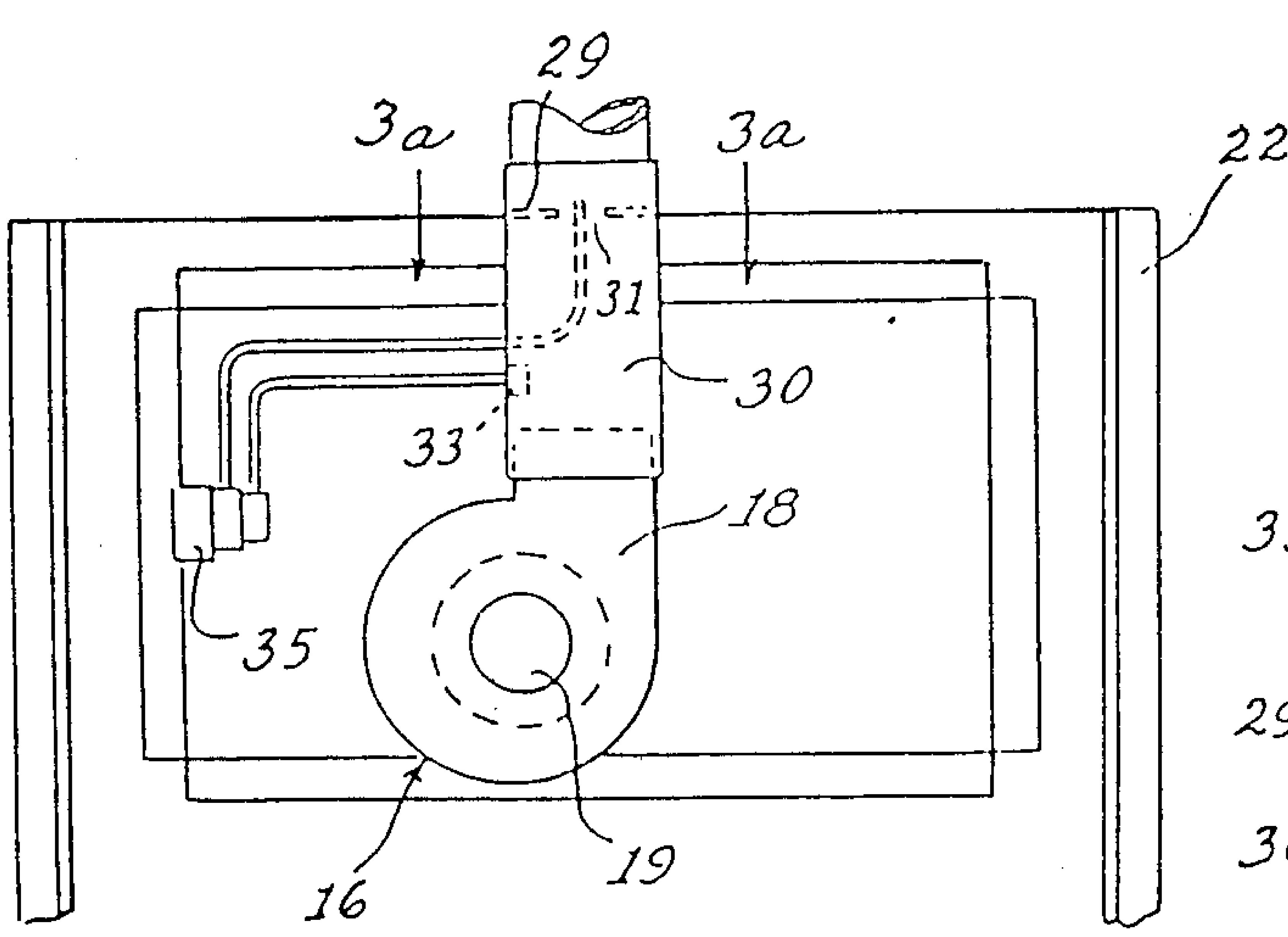


Fig. 3.

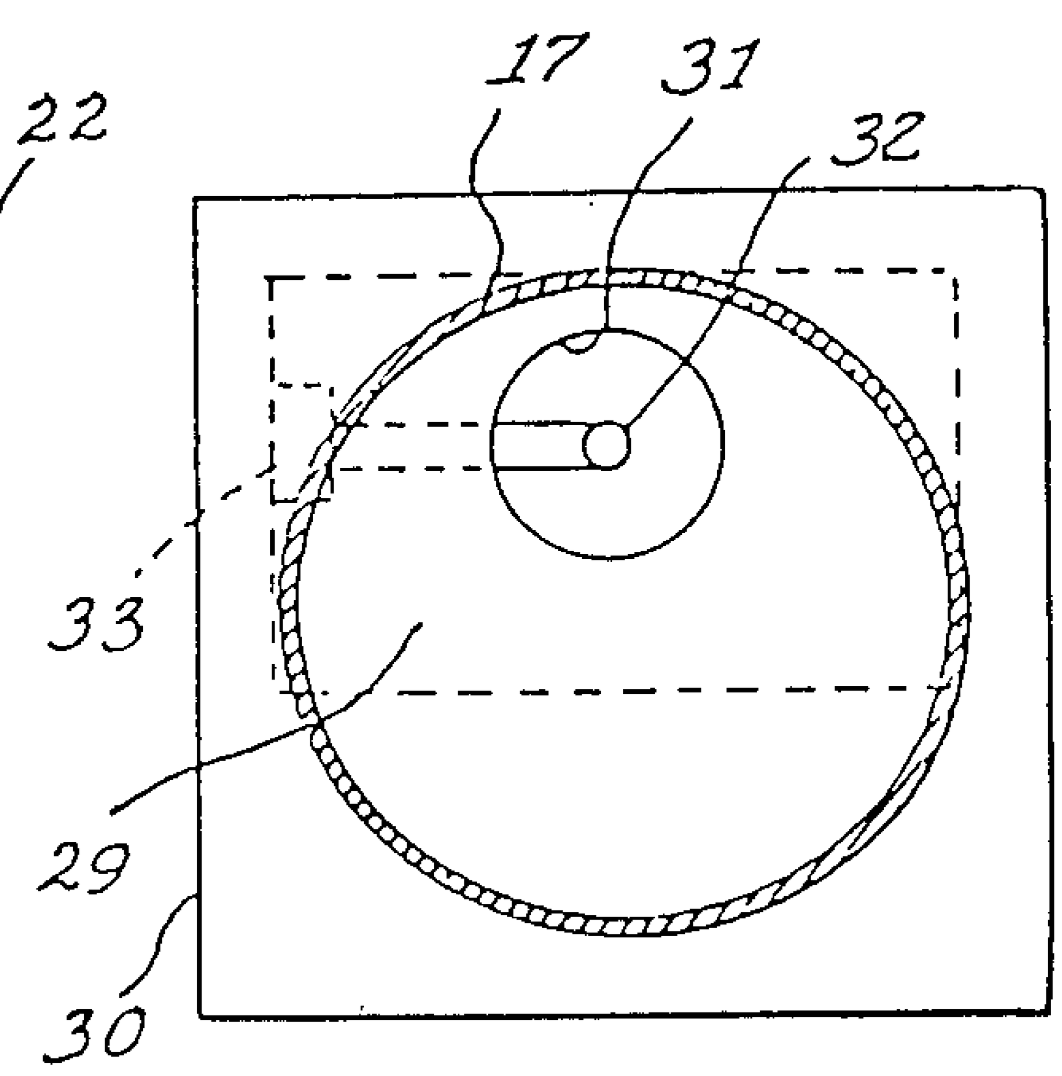
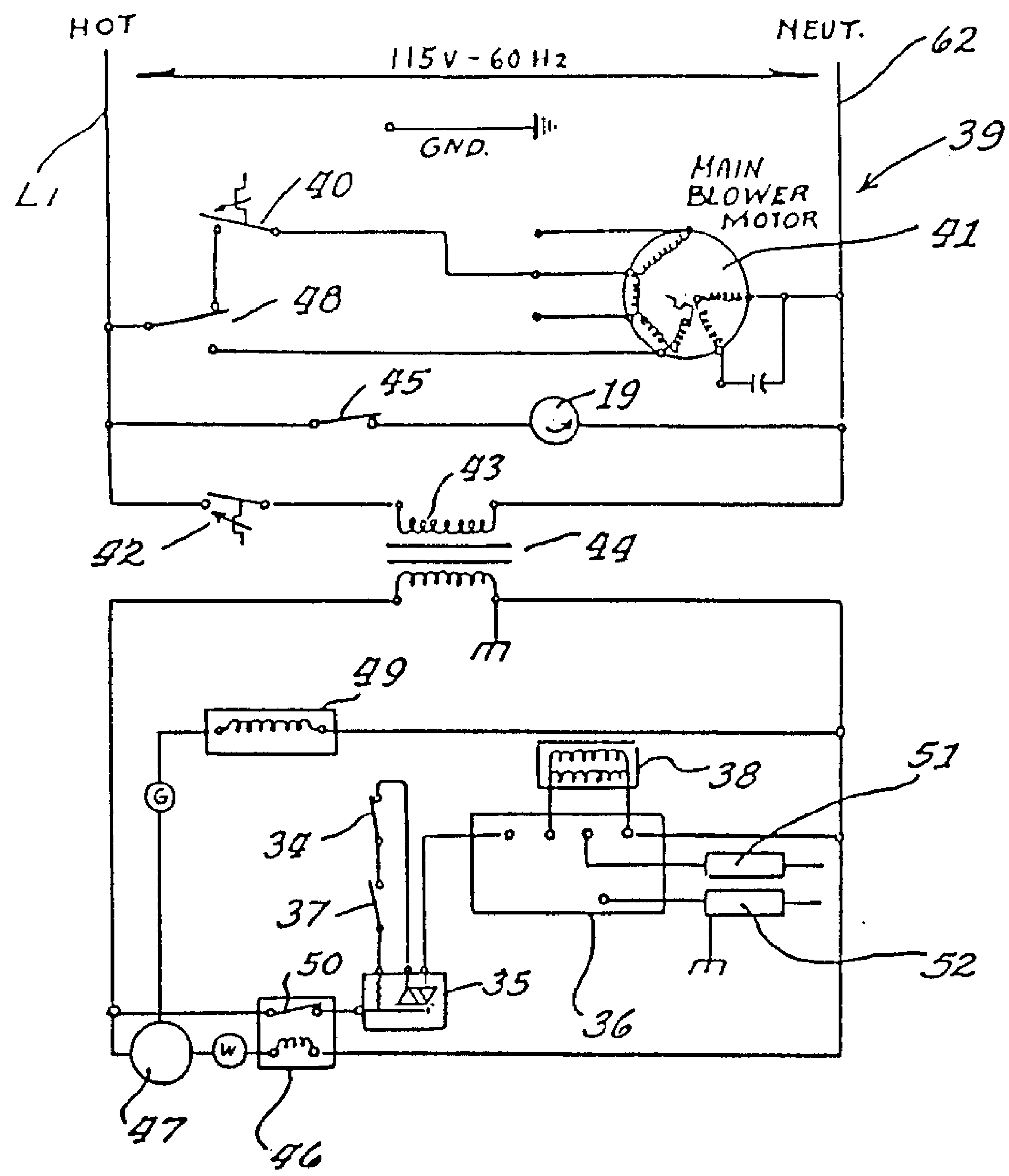


Fig. 3a.

Fig. 4


HOT
NEUT.
115V-60Hz
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MAIN BLOWER MOTOR
L1
62
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40
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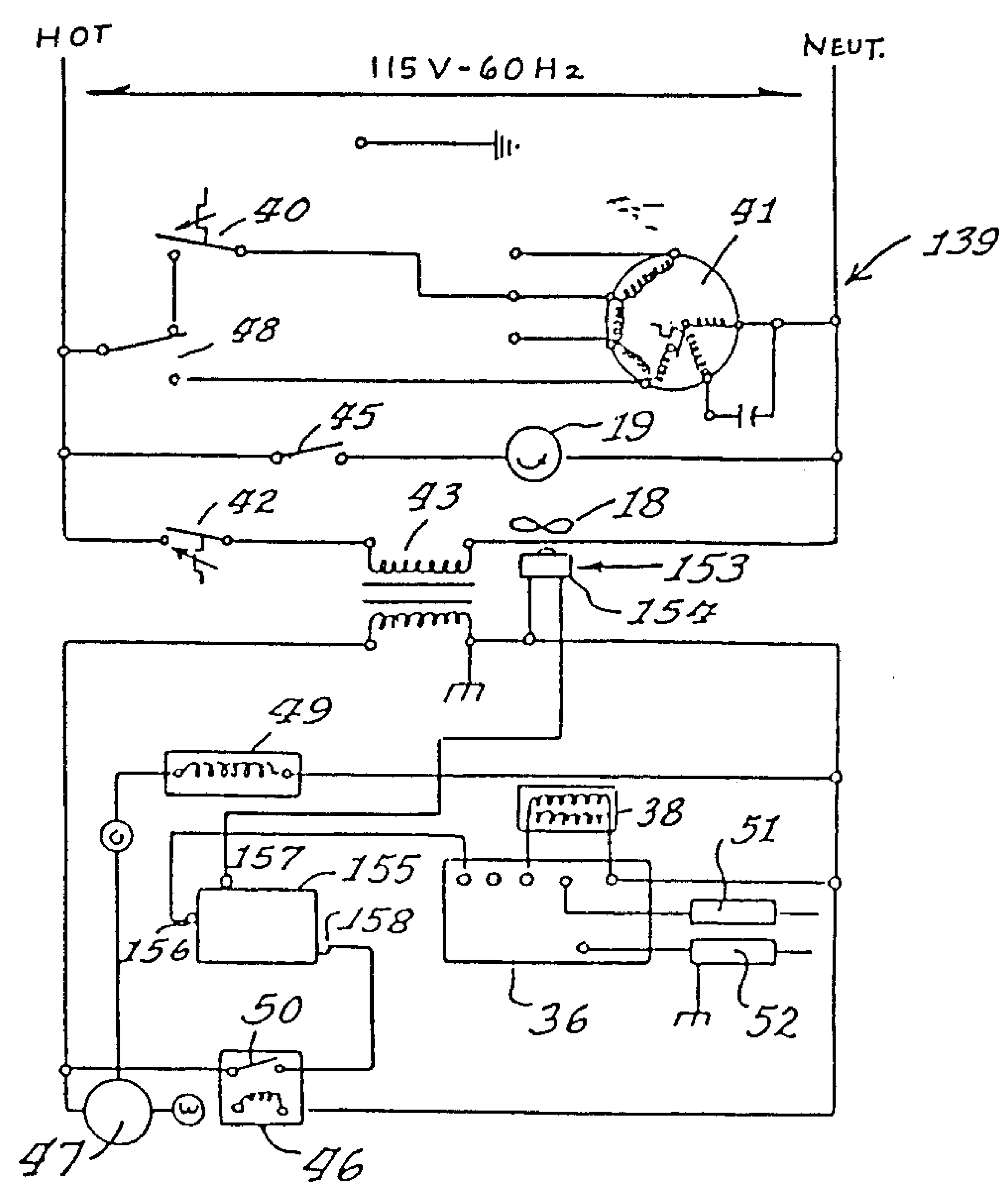
Fig. 5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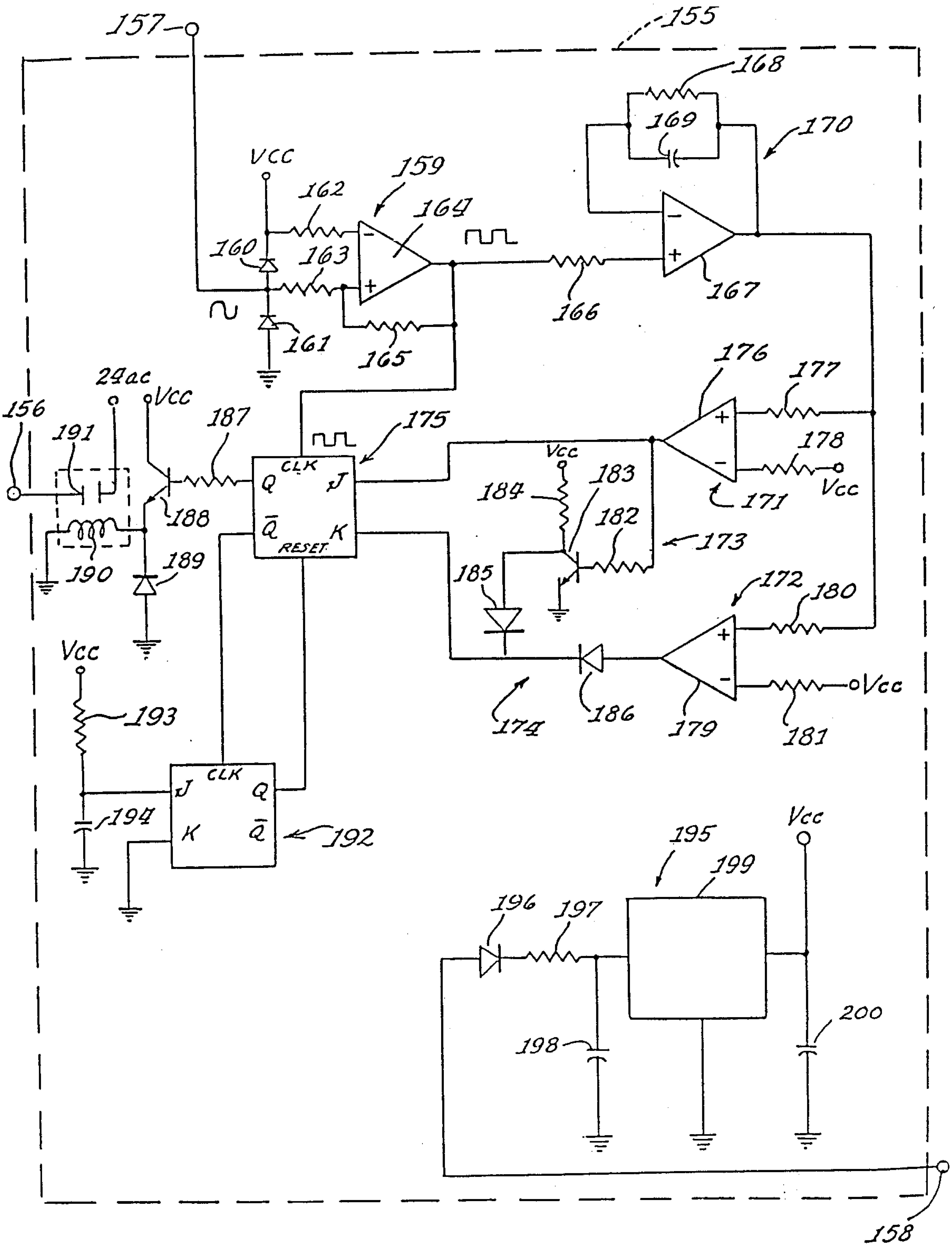

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Vcc
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171
Vcc
188
Q̄
K
RESET
182
173
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189
185
172
180
Vcc
193
186
179
181
174
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158

Fig. 6.

FIG. 7

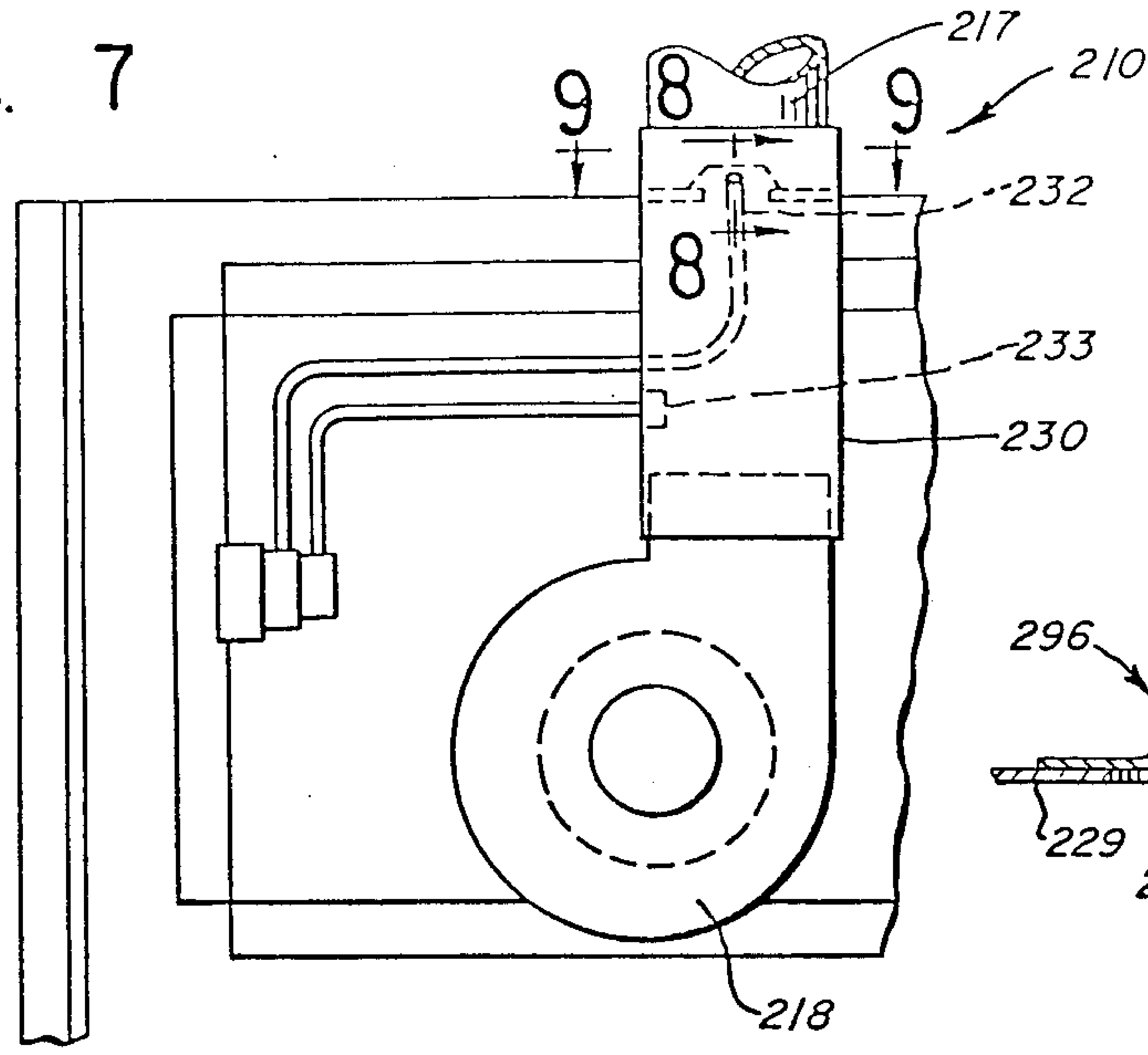


FIG. 8

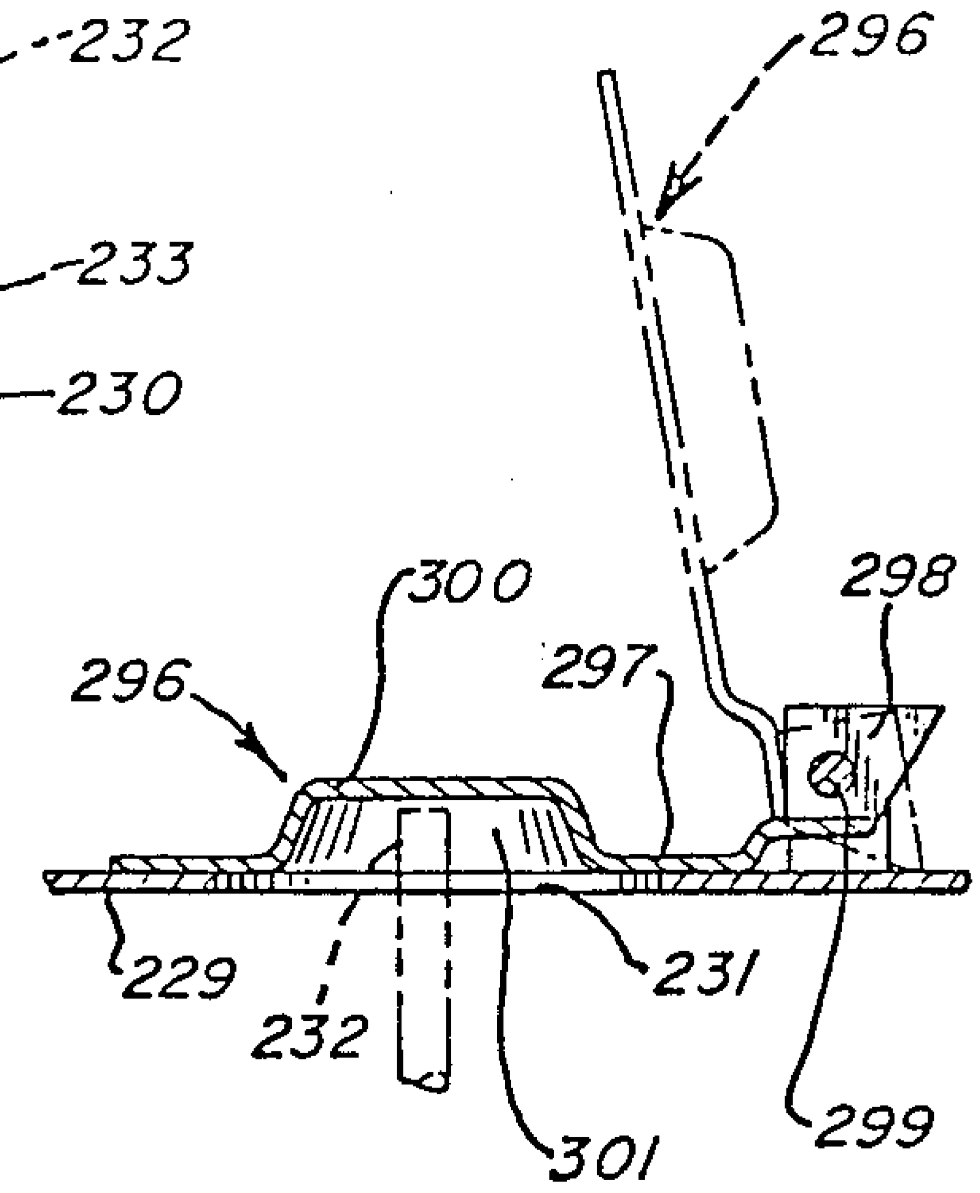
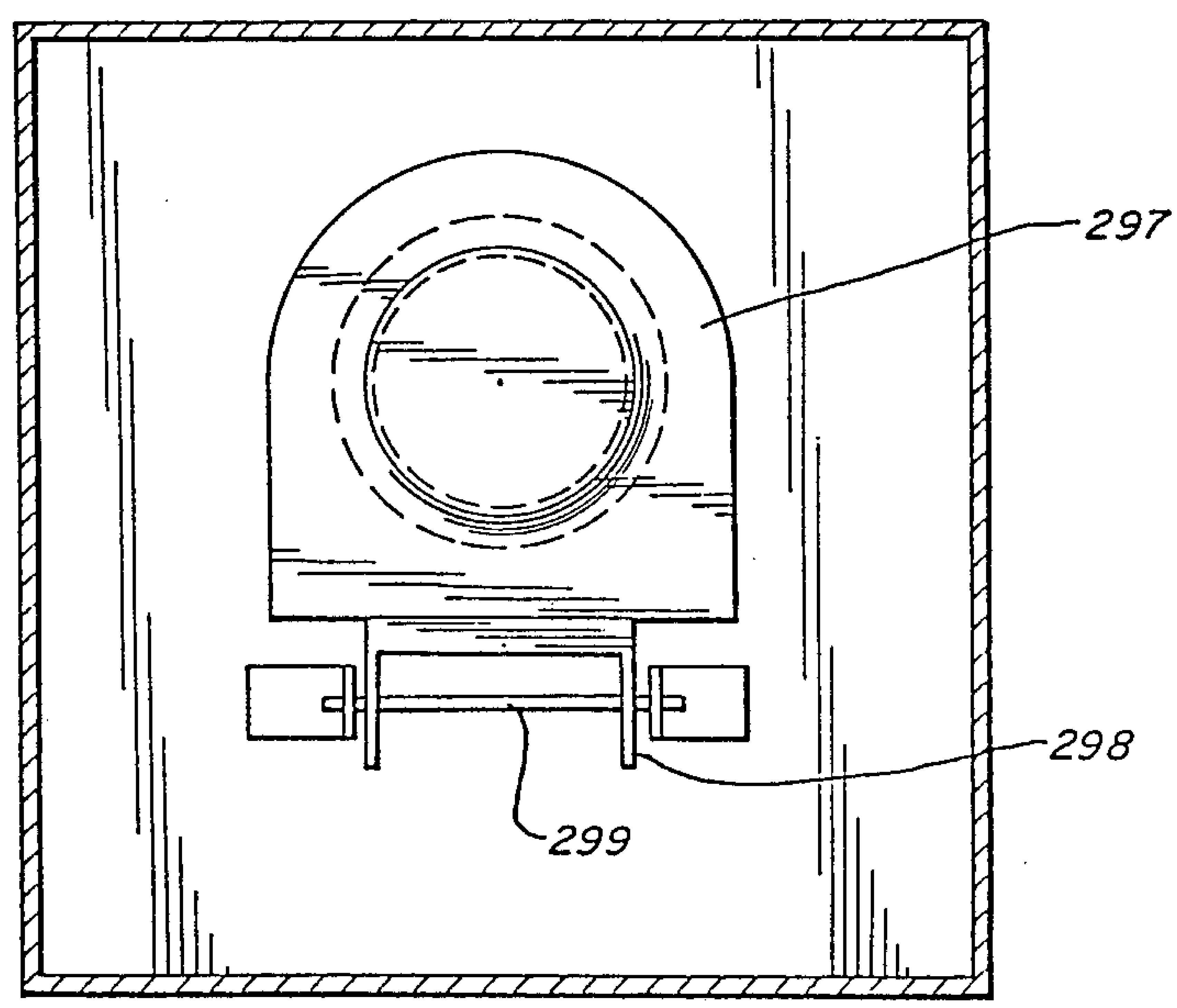


FIG. 9



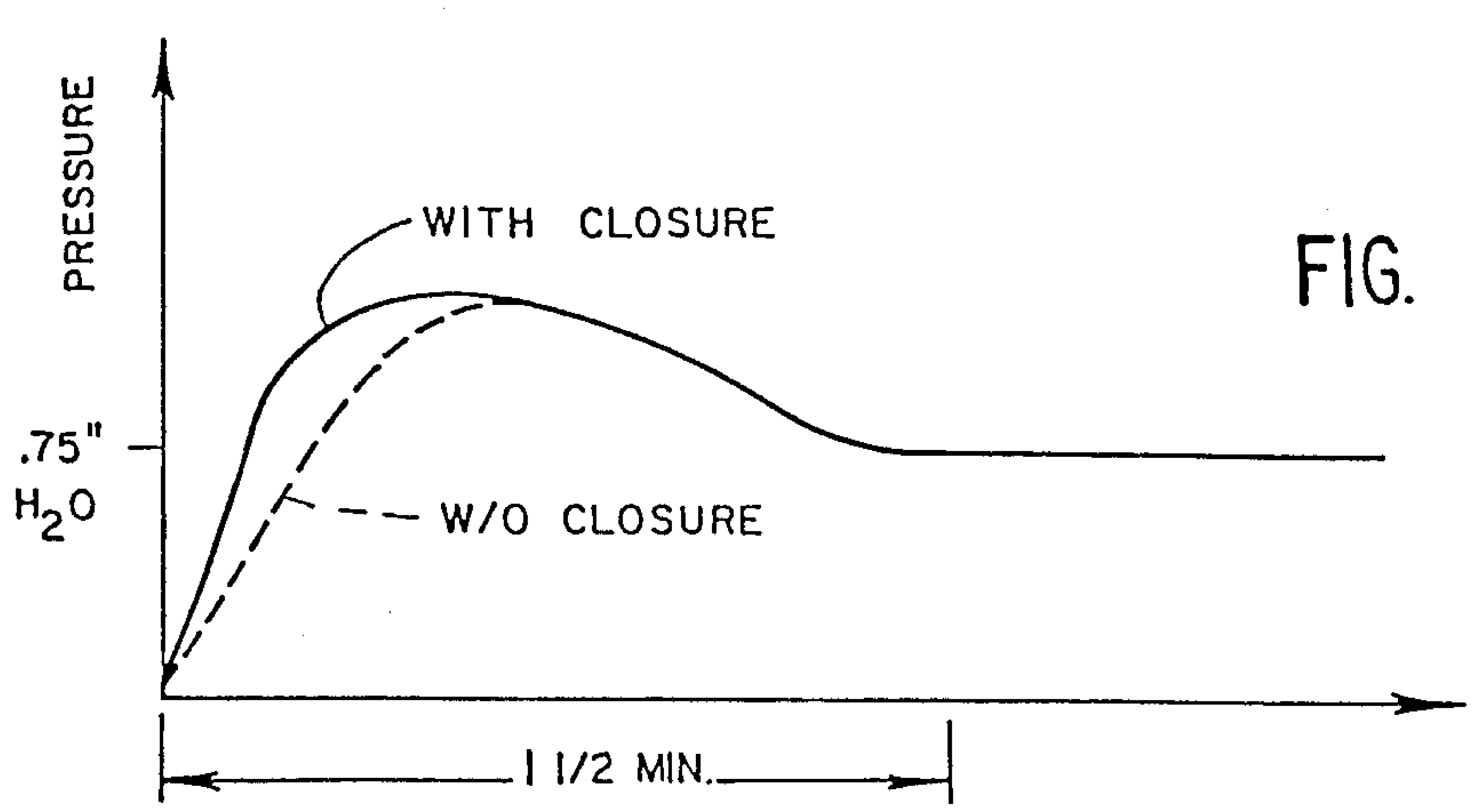


FIG. 10

POWER VENT AND CONTROL FOR FURNACE

BACKGROUND OF THE INVENTION

Cross-Reference to Related Applications

This application comprises a continuation of my copending application Ser. No. 338,664, filed Jan. 11, 1982, entitled "Power Vent and Control for Furnace", now U.S. Pat. No. 4,460,329, which was a continuation-in-part of application Ser. No. 116,021, filed Jan. 23, 1980, entitled "Power Vent and Control for Furnace", now abandoned.

This invention relates to heating means, such as furnaces, and in particular to a power vent system and control suitable for use in domestic furnaces.

DESCRIPTION OF THE PRIOR ART

In one form of heating device, such as a furnace, oven, dryer, or the like, means have been provided for forcibly exhausting the products of combustion from the combustion chamber. In the event of a failure of the exhausting means to provide the desired discharge, it has been conventional to provide control means for preventing further delivery of fuel to the combustion chamber. It has further been known to provide, in such a control, means for preventing delivery of the fuel to the combustion chamber until such time as at least a minimum exhaust functioning has been established.

It has further been conventional in the prior art furnace controls to provide a flow limiting orifice in the exhaust stack in proximity to the air moving means for causing a pressure differential whereby a pressure signal may be generated representative of the flow rate of the exhaust stack gases at the orifice.

It is further known to determine the operation of the air moving means as by use of a centrifugal switch or the like. It is also known to provide controls for preventing delivery of fuel to the combustion chamber until such time as the exhaust fan generates sufficient suction pressure to assure proper operation of the furnace.

It is further conventional to provide a reverse flow check valve in the exhaust flue, or vent, so as to prevent passage of downdrafts to the furnace.

SUMMARY OF THE INVENTION

The present invention comprehends an improved power vent and control for use in combustion heating apparatus, such as a furnace or the like.

The invention comprehends the provision of a restricted flow passage in association with a power vent blower. The restricted flow passage may comprise a reduced size outlet flue and an orifice plate arranged to restrict natural thermal convective updraft through the flue but yet permit adequate removal of the products of combustion when the vent blower is operative. Any one of a plurality of orifice plates, each having a different size orifice therein, may be used with a given size furnace to thereby determine the amount of heat exchange while utilizing a single size motor-driven power vent blower.

In a first embodiment, the control is responsive to a pressure condition existing downstream of the power vent blower. In this embodiment, the control may include sensing means for sensing the pressure condition at an orifice provided downstream of the vent blower. The sensing means may further include means for sensing the static air pressure upstream of the orifice.

In a second embodiment, the invention utilizes means for sensing the speed of the air moving means. In this embodiment, the speed is sensed by a magnetic pickup device which illustratively senses the rotation of the blower vanes.

To provide improved speed sensing control, the blower motor is preferably one which increases in speed substantially in the unloaded condition. In the illustrated embodiment, the blower motor comprises a shaded pole motor providing such desired functioning.

To further enhance the speed control functioning, the blower illustratively comprises a blower which unloads under high discharge pressure conditions, such as when the flue is blocked. In the illustrated embodiment, a centrifugal blower is utilized to provide this desirable functioning.

The control may be made responsive to either underspeed or overspeed conditions so as to protect the system against a wide range of malfunctioning conditions.

The control provides a fail-safe functioning by shutting down the fuel supply under the different conditions.

In another embodiment of the invention, flow control means are provided for controlledly obstructing fluid flow through the orifice. More specifically, in this embodiment the flow controlling means includes a gravity-biased closure selectively extending across the orifice to close the orifice when the fluid moving means is not in operation. The closure is movably mounted so as to move away from the orifice as a result of fluid flow induced through the orifice upon initiation of operation of the fluid moving means.

The flow control means is arranged to cause an increased rate of rise of the pressure sensed by the pressure sensor upstream of the orifice so as to provide an improved sensing operation.

The pressure sensing means further serves to detect a lack of proper air flow such as in the event the closure fails to open the orifice.

In the illustrated embodiment, a flow sensing element is disposed in the orifice. More specifically, in the illustrated embodiment, the flow sensor extends upwardly through the orifice and the closure plate is provided with a recess portion receiving the flow sensor when the closure plate is in the closed position across the orifice.

Thus, the flow sensing means is disposed effectively at the position where highest fluid flow velocity is obtained, while yet the apparatus is arranged to effectively close the orifice in the nonoperating condition of the apparatus.

The invention comprehends that the closure be selectively operated by positive means, such as an electrically operated solenoid or the like. Further, while the invention is disclosed utilizing a flow sensing means at the orifice, the invention further comprehends the provision of pressure sensing means at opposite sides of the orifice for use in controlling the operation of the apparatus, such as by means of a control utilizing a single pressure responsive diaphragm.

The power vent and control of the present invention are extremely simple and economical of construction while yet providing the highly desirable features discussed above.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawings wherein:

FIG. 1 is a fragmentary perspective view of a furnace having a power vent system embodying the invention;

FIG. 2 is a schematic diagram of the furnace;

FIG. 3 is a fragmentary elevation illustrating in greater detail the arrangement of the pressure sensing means;

FIG. 3*a* is a fragmentary enlarged horizontal section taken substantially along the line 3*a*—3*a* of FIG. 3;

FIG. 4 is a schematic wiring diagram of the control circuitry of the embodiment of FIGS. 1-3;

FIG. 5 is a schematic wiring diagram showing a modified form of control utilizing a magnetic sensor for sensing the speed of the air moving means;

FIG. 6 is a schematic wiring diagram of the control device for providing a control signal from the magnetic pickup means of the control of FIG. 5;

FIG. 7 is a fragmentary elevation illustrating another form of power vent system embodying the invention and showing in detail the arrangement of the pressure and fluid flow sensing means thereof;

FIG. 8 is a fragmentary enlarged vertical section showing in greater detail the orifice closing means thereof;

FIG. 9 is an enlarged transverse section taken substantially along the line 9—9 of FIG. 7; and

FIG. 10 is a graph illustrating the improved rapid rise of the pressure sensed by the pressure sensing means of the embodiment of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the exemplary embodiments of the invention as disclosed herein, a combustion device **10** illustratively comprises a furnace having a burner **11** for providing in a combustion chamber **12** a flame **13**. The products of combustion are passed through a heat exchanger **14** to a manifold **15**. The manifold is positively exhausted by power vent means **16** to an outlet flue **30** which is typically connected to a flue pipe **17**. The power vent means may include a blower **18** driven by a motor **19**. Fuel is delivered to burner **11** through a control valve **20**. A primary air mover assembly **21** causes the primary air to flow in heat exchange relationship with the heat exchanger **14**, thereby heating the primary air.

In the illustrated furnace of FIG. 1, the furnace includes an outer cabinet **22** defining a blower compartment **23** and a discharge plenum **24** for the primary air. Mounted within a control space **25** at the front of the furnace are control elements, such as a conventional gas valve **20**, a restrictor **26** defining an inlet for secondary air, a fan limit control **27**, and a pre-purge time delay and post-purge control **28**.

As indicated above, the invention comprehends an improved power vent means and improved means for controlling its operation. Specifically, as shown in FIGS. 3 and 3*a*, an orifice plate **29** may be provided in a tubular connector **30** connecting the blower **18** to the flue pipe **17**. The orifice plate defines an orifice **31**. The present invention comprehends that the orifice plate **29** may be any one of a plurality of orifice plates having different size orifices corresponding to different air flow rates desired for different size furnaces, while permitting the use of a single size air moving means **16**. The use of blower **18** also permits the diameter of the furnace outlet flue **30** and associated flue pipe **17** to be reduced. More specifically, the size of the orifice provides a predetermined load on the air moving means **16** which, in turn, determines the flow rate for the air moving means **16** and, thus, the furnace heating capacity. By way of example, for a domestic gas furnace having a three-inch diameter flue and using a Torin No. FE-416-108-1 centrifugal blower serving as the vent blower, the heating capacity and corresponding orifice size may be related as follows:

Furnace Capacity	Orifice Diameter
125,000 BTUH	1⅝″
105,000 BTUH	1½″
80,000 BTUH	1 5/16″

It is desirable in practicing the present invention to restrict natural convective thermal updraft as much as possible during off cycles, and the use of the power vent blower allows the flow path for the combustion products to be restricted to such an extent that during operation of the burner, adequate removal of the products of combustion will not take place by such natural convective flow.

As illustrated in FIGS. 3, 3*a* and 4, means are provided for determining the pressure conditions within the outlet flue **30** and, by way of example, include a Pitot tube pressure sensor **32** in the orifice **31** and a static pressure sensor **33** within the outlet flue **30** upstream of the orifice.

The Pitot tube sensor **32** senses the negative pressure created by the orifice as a result of the normal air flow from blower **18** therethrough. In the event of blockage of the flue pipe **17**, the air flow is decreased and the decrease is sensed by the sensor **32** to open a single pole, normally closed blockage switch **34** connected in series with a triac **35** for controlling a conventional direct spark ignition control **36**. In series with the blockage switch **34** is a normally closed air pressure switch **37** controlled by the static pressure sensor **33**. Pressure switch **37** senses the pressure caused by the flow of sufficient air to provide for proper combustion in the furnace.

The solenoid coils **38** for controlling the gas valve **20** are connected to the control **36**, as shown in FIG. 4, so as to be controlled by the operation of switches **34** and **37**.

As shown in FIG. 4, furnace control **39** may be energized from power supply leads L1 and L2. The control includes a fan control **40** connected in series with the main blower motor **41** of primary air mover **21**. A limit control switch **42** is connected in series with the primary winding **43** of a control transformer **44** across the power supply leads L1 and L2. Switches **40** and **42** comprise thermostatic switches sensing the temperature of the air heated by the heat exchanger **14**. Switch **40** closes to energize motor **41** of main blower **21** when the sensed temperature is approximately 120° F. and opens to discontinue operation of the motor **41** when the temperature drops below 90° F.

Operation of the power vent blower motor **19** is controlled by contacts **45** of a relay **46** in series with a main thermostat **47** of the heating system.

A single pole, double throw contact **48** is operated by a relay **49** which is controlled by a switch in thermostat

47, which may be set by the user to select continuous or automatic operation of the main blower 21.

As shown, relay 46 includes normally open contacts 50 which are in series with the spark ignition module 36 to provide power thereto under the control of thermostat 47.

As further shown in FIG. 4, the spark ignition module 36 receives an input from a flame conductivity sensor 51 and operates a spark igniter 52 and the fuel supply valve coil 38.

In normal operation, thermostat 47 energizes relay 46 to call for heating output of the furnace. This closes the contacts 50 to energize the spark igniter control 36 so as to initiate a heating operation by delivery of fuel to the burner 11 under control of valve 20. When the air temperature sensed by switch 40 reaches the selected temperature, switch 40 closes, thereby energizing the main blower motor 41 and commencing delivery of heated air from the furnace.

At the same time relay 46 closes contacts 50, it closes contacts 45 to energize the power vent motor 19. The normal flow of secondary air and the combustion products through orifice 31 is sensed by the sensor 32, maintaining switch 34 closed. However, if a restriction occurs in the flue pipe 17, the negative pressure on sensor 32 decreases (toward zero) and may go positive, so as to open the contacts 34 to de-energize the triac 35 and correspondingly de-energize the ignition control 36 to close valve 20 and thereby prevent further delivery of fuel to the combustion chamber.

If for any reason during the operation of the furnace the pressure sensed by static pressure sensor 33 drops below a preselected value, switch 37 is caused to open, thus similarly de-energizing triac 35 and the ignition control 36 to de-energize coil 38 and thereby close fuel valve 20 and shut down the furnace.

The power vent means 16 provides a negative pressure within the combustion chamber 12 sufficient to overcome variations in the natural draft. The power vent provides improved efficiency in the operation of a furnace by reducing the amount of excess air required in the combustion process, thereby allowing a more optimum air/fuel ratio to be achieved. In addition, the restricted flow passage provided by the power vent blower 18, the orifice 31 and the reduced diameter of flue 30 reduces convective off cycle heat loss through the system. The thermal efficiency of conventional, natural draft furnaces is limited to approximately 75 percent. The use of the power vent described herein provides a highly desirable increase in the efficiency, and efficiencies of 85 percent are easily obtained. By means of the improved control provided by switches 34 and 37, a safe, highly efficient operation of the furnace is obtained.

It will be appreciated by those skilled in the art that the flow path for the combustion products can be restricted in various alternative ways to produce the desired reduction in off cycle losses while yet permitting adequate removal of the combustion products during periods when the vent blower 18 is operating.

Referring now to the embodiment of FIGS. 5 and 6, a modified form of control generally designated 139 is shown to comprise a control generally similar to control 39, but utilizing a modified means for determining the operating condition of the power vent means. More specifically, as shown in FIG. 5, modified control 139 utilizes a speed sensor generally designated 153 for determining if the blower 18 or, alternatively, motor 19, is operating within a desired speed range. In one illustrative form, as shown in FIG. 5, the speed sensor comprises a magnetic pickup 154 arranged to count revolutions of the blower 18. Sensor 154 is connected to a control 155 which converts the sine wave output of sensor 154 to a suitable signal for controlling the spark ignition module 36. As mentioned above, a blockage in the flue causes the blower 18 to unload as a result of the high discharge pressure encountered. A centrifugal blower is preferably employed for this purpose. Further, motor 19 is preferably a motor whose speed increases appreciably when it is unloaded and, illustratively, motor 19 may comprise a Torin No. 60054 shaded pole motor. In one set of illustrative parameters, the speed of the motor under normal load is approximately 2600 RPM, with the unloaded speed being approximately 3200 RPM.

Referring now to FIG. 6, control 155 has an output 156 connected to the spark igniter control 36, an input 157 connected to the magnetic sensor 154, and an input 158 connected to switch 50 of relay 46. As shown, circuit 155 includes a Schmitt trigger generally designated 159 for shaping the input sine wave. As shown, the trigger includes a pair of diodes 160 and 161 connected through resistors 162 and 163 to the inverting and non-inverting input of an operational amplifier 164, having a resistor 165 connected between the non-inverting input and the output thereof.

As shown, the square wave output of the Schmitt trigger is delivered through a resistor 166 to the noninverting input of an operational amplifier 167 used as a tachometer, generally designated 179. An averaging network including a resistor 168 and a capacitor 169 is connected between the non-inverting input and output of the operational amplifier 167. The output of the tachometer 170 is delivered to a pair of level detectors 171 and 172 whose outputs are combined through an inverter 173 and OR gate 174 and supplied to the K terminal of a JK flip-flop 175. As shown, level detector 171 comprises an operational amplifier 176 having its noninvering input connected through a resistor 177 to the output of operational amplifier 167, and its inverting input connected through a resistor 178 to the power supply. Level detector 172 comprises an operational amplifier 179 having its noninverting input connected through a resistor 180 to the output of operational amplifier 167, and its inverting input connected through a resistor 181 to the power supply.

The output of operational amplifier 176 is connected to a resistor 182 of inverter 173, which resistor is in turn connected to the base of a transistor 182 having its collector connected to the power supply through a resistor 184 and its emitter connected to ground. The collector is also connected through a diode 185 to the K terminal of the JK flip-flop 175. The output of operational amplifier 179 is connected through a diode 186 to the K terminal of flip-flop 175 also.

The square wave output of Schmitt trigger 159 is further delivered to the clock contact of the JK flip-flop 175, which is in turn connected to a relay driver circuit 187, comprising a transistor 188 having its collector connected to the power supply, its base connected through resistor 200 to the Q output of flip-flop 175, and its emitter connected through a diode 189 to ground. The emitter is further connected to a relay coil 190 for controlling a normally open contact 191 connected between the power supply and terminal 156 which, as discussed above, is connected to the spark igniter 36.

Control **155** further includes a second JK flip-flop **192** having its clock terminal connected to the $\overline{Q}$ output of the flip-flop **175** and its Q terminal connected to the reset terminal of flip-flop **175**. The J terminal of flip-flop **192** is connected through a resistor **193** to the power supply and through a capacitor **194** to ground. The K terminal of flip-flop **192** is connected to ground.

The power supply **195** is connected to the terminal **158** of control **155**, from which it receives low voltage AC whenever switch **50** is closed and power is supplied to control transformer **44**. As shown in FIG. **6**, the power supply includes a diode **196** and a resistor **197** connected in series between terminal **158** and a 15-volt LC regulator **199**. A capacitor **198** is connected from resistor **197** to ground. The output of the regulator, in turn, is connected to the power supply terminal Vcc and through a capacitor **200** to ground. The connections between the Vcc terminal of regulator **199** and the Vcc terminals illustrated in connection with the other portions of the control circuit are omitted for simplification of the schematic wiring diagram.

The operation of control **155** in controlling the spark igniter **36** is based on the control of contacts **191** as a function of the frequency of the signal delivered to Schmitt trigger **159** from the speed sensor **153** connected to control terminal **157**. In the operation of the control, flip-flop **175** changes from a low to a high state when a 1 is present at the J input and a clock pulse from the Schmitt trigger is received at the clock input. The presence of a 1 at the K input of flip-flop **175** causes the flip-flop to reset so as to have a low output upon receipt of a clock pulse.

When the output of flip-flop **175** goes high, relay coil **190** is energized so as to close contacts **191** and thereby provide power to the spark ignition module **36** through output terminal **156**.

Flip-flop **192** serves as a latch for flip-flop **175**, holding flip-flop **175** in the "off" state whenever it has been shut down due to the presence of a failure signal delivered from sensor **153** to the input terminal **157** of control **155**.

The J and K inputs of flip-flop **175** are controlled by the level detectors **171** and **172**. The detectors are biased so that a 1 is produced by detector **171** whenever the speed sensed by sensor **153** is above a predetermined desired minimum, such as 2600 RPM, and level detector **172** produces a 1 at its output whenever the sensed speed is above a predetermined maximum, such as 3200 RPM.

Under normal operating conditions wherein the speed of the blower is within the desired range of 2600 RPM to 3200 RPM, level detector **171** is effective to provide a 1 at the J input of flip-flop **175**. The clock pulse received from Schmitt trigger **159** thus immediately clocks the flip-flop into an "on" condition wherein the Q output goes high, thereby energizing the relay coil **190** as discussed above.

In the event the sensed speed drops below the preselected minimum, such as 2600 RPM, the output of level detector **171** drops to zero, and the inverter circuit **173** causes a 1 to appear at the K input to flip-flop **175** so that upon receipt of the next clock pulse, flip-flop **175** resets, thereby deenergizing the relay coil **190**.

In the alternative event that the sensed speed rises above the preselected maximum, such as 3200 RPM, each of the level detectors **171** and **172** provides a 1 output. The 1 output of level detector **172** will be supplied to the K input of flip-flop **175** through operation of the OR gate formed by diodes **185** and **186**, notwithstanding the 1 output from level detector **171**. Under this condition, on the next clock pulse the flip-flop **175** will be reset to de-energize relay coil **190** under this high-speed blower condition.

The averaging network **168**,**169** associated with tachometer **170** provides a DC level signal which is proportional to the fan speed, which signal is delivered to the noninverting input of the level detector amplifiers **176** and **179**.

It will be appreciated that control **155** provides safety protection of the furnace under a number of different failure conditions, such as undervoltage, overvoltage, blower failure, and vent blockage. The control permits the use of the highly desirable power vent in providing improved fuel efficiency in the operation of the furnace and decreased off cycle losses.

Since the ignition control **36** requires energization of coil **190** for its operation, a fail-safe function is provided in connection with any of the above-discussed system failures, as well as any failure of the control circuitry **155**.

Referring now to the embodiment of FIGS. **7**–**10**, a further improved modification of the combustion apparatus is shown to comprise a combustion apparatus generally designated **210** similar to apparatus **10** but further including an improved flow control means generally designated **296** for selectively restricting the flow through the orifice **231** defined by the orifice plate **229**. Flow control means **296** effectively define means for providing an initial increased rate of rise of the static pressure upstream of the orifice **231** each time the blower **218** is energized. More specifically, as illustrated in FIG. **10**, flow control means **296** causes the static pressure sensed by sensor **233** to increase more rapidly upon initial energization of the blower **218** than the rate of static pressure increase associated with the operation of apparatus **10**, as illustrated in FIG. **3**. This effect is very brief and is a result of the orifice **231** being initially closed by the flow control means **296** when blower **218** is first energized. The resulting increased rate of pressure build-up provides a more positive operation of the switch (not shown) associated with the static pressure sensor **233**, and this is highly advantageous because the pressure differential to which the switch must respond is relatively small, as illustrated.

The combustion apparatus **210** permits flow sensor **232** to be disposed such that it extends through the orifice **231**, as illustrated in FIG. **8**. Thus, the flow sensor is disposed at a location in the system where effectively maximum flue gas velocity exists. Accordingly, the flow sensor **232** is exposed to the largest negative pressure during normal operation of the apparatus.

As illustrated in FIGS. **8** and **9**, the flow control means **296** comprises a closure plate or damper **297** having a mounting portion **298** pivotally mounted to the orifice plate **229** by a suitable pivot means **299**. In the closed position, closure plate **297** facially engages the upper surface of orifice plate **229**. The midportion of the closure plate defines an upwardly projecting boss **300** defining a space **301** opening toward orifice **231** and receiving the end of the flow sensor **232**, as shown in FIG. **8**.

The closure plate is gravity-biased by its weight so as to close the orifice **231** in the absence of blower-induced air flow upwardly through orifice **231**. Upon initiation of the blower **218**, air flow upwardly through orifice **231** causes the closure plate to swing from the full line position of FIG. 8 to the dotted line position, while causing the above-discussed rapid static pressure rise upstream of the orifice plate adjacent the sensor **233**.

Should the closure plate **297** fail to move from the closed position, the flow sensor **232** immediately detects the failure of air flow through the orifice, thereby permitting the control to de-energize the furnace in accordance with the control operation described above relative to the previously described embodiments. Thus, the flow sensor operates to sense the position of the closure plate and need for an additional sensing device to determine the position of the closure plate is obviated.

While the illustrated embodiment discloses a gravity-biased closure plate, as will be obvious to those skilled in the art, other forms of closure plate control means may be utilized, including electrically operated solenoids and the like, within the scope of the invention.

Further, while the invention has been disclosed utilizing a static pressure sensor **233** in combination with a flow sensor **232**, as will be obvious to those skilled in the art, the control may utilize a pair of pressure sensors on opposite sides of the orifice and include a single pressure responsive diaphragm control connected to sense the pressure differential.

The use of the closure plate further improves the operating efficiency of the combustion apparatus by preventing convective flow through the flue when the apparatus is inoperative. It has been found that an improvement in operating efficiency in the range of approximately 3% is thusly obtained.

As in the previous embodiments, the flue pipe **217** and the outlet flue **230** may have a cross section which is smaller in area than that necessary in the absence of a powered blower to effectively vent the combustion chamber for suitable operation of the furnace. The control means of the previously described embodiments may, therefore, be utilized with the apparatus **210**. Thus, the control means may include means for sensing the speed of the blower coupled to the control to prevent energization of the blower whenever the speed sensed falls outside a predetermined desired range. The blower may include a drive motor having load speed characteristics such that the motor speed increases substantially when unloaded and the sensing means comprises means for sensing the speed of the motor. Further, the apparatus **210** may be arranged for preventing combustion in the combustion chamber until the air moving means reaches at least a preselected minimum speed.

Still further, the orifice means of apparatus **210** may comprise means for mounting across the vent any one of a plurality of orifice plates each having an orifice therein, with the orifices of the respective plates differing in size for providing selectively different flow rates therethrough.

The apparatus **210** may utilize a speed sensing means comprising a magnetic pickup means responsive to rotation of a rotated metal portion of the air moving means.

The control illustratively may include means responsive to the speed sensing means for preventing delivery of fuel by the delivery means whenever the sensed speed of the air moving means is above a first predetermined speed or below a second lower predetermined speed.

The foregoing disclosure of specific embodiments is illustrative of the broad inventive concepts comprehended by the invention.

I claim:

1. In a heating apparatus such as a furnace having a combustion chamber, delivery means for delivering combustible fuel to said chamber for combustion therein, an outlet flue, and blower means connected to said outlet flue for effecting the flow of combustion products therethrough, the improvement comprising:

means defining a flow restricting orifice disposed within said outlet flue, said orifice defining the smallest flow passage within said apparatus through which said combustion products are caused to flow and having a size determined by the desired firing rate of said apparatus;

flow sensing means aligned with the center of said flow restricting orifice to be in the portion of the fluid flow through the orifice of least turbulence and arranged to provide an output signal only in response to sensing a preselected rate of flow outward through said orifice; and

control means responsive to said flow sensing means for preventing operation of said fuel delivery means when said sensing means indicates less than said preselected flow through said orifice subsequent to initiation of operation of said blower means.

2. The heating apparatus of claim **1** wherein said flow sensing means comprises a Pitot tube sensor opening adjacent said center of the flow restricting orifice.

3. The heating apparatus of claim **1** wherein said flow sensing means is disposed at said center of the orifice.

4. The heating apparatus of claim **1** further including means for sensing static pressure upstream of the orifice for providing a signal to said control means for further controlling operation of the fuel delivery means.

5. In a heating apparatus such as a furnace having a combustion chamber, delivery means for delivering combustible fuel to said chamber for combustion therein, an outlet flue, and blower means connected to said outlet flue for effecting the flow of combustion products therethrough, the improvement comprising:

means defining a flow restricting orifice disposed within said outlet flue downstream of said blower means, said orifice defining the smallest flow passage within said apparatus through which said combustion products are caused to flow and having a size determined by the desired firing rate of said apparatus;

flow sensing means adjacent the center of said flow restricting orifice in the portion of the fluid flow through the orifice of least turbulence and arranged to provide an output signal only in response to sensing a preselected rate of flow outward through said orifice; and

control means responsive to said flow sensing means for preventing operation of said fuel delivery means when said sensing means indicates less than said preselected flow through said orifice subsequent to initiation of operation of said blower means.

6. The heating apparatus of claim **5** wherein said flow sensing means is disposed downstream of said center of the orifice.

7. The heating apparatus of claim **5** wherein said flow sensing means comprises a Pitot tube sensor.

8. The heating apparatus of claim **5** further including means for sensing static pressure upstream of the orifice for providing a signal to said control means for further controlling operation of the fuel delivery means.

9. In a heating apparatus such as a furnace having a combustion chamber, delivery means for delivering combustible fuel to said chamber for combustion therein, an outlet flue, and blower means connected to said outlet flue for effecting the flow of combustion products therethrough, the improvement comprising:

means defining a flow restricting orifice disposed within said outlet flue, said orifice defining the smallest flow passage within said apparatus through which said combustion products are caused to flow and having a size determined by the desired firing rate of said apparatus;

flow sensing means positioned closely downstream of the center of said flow restricting orifice to be in the portion of the fluid flow through the orifice of least turbulence and arranged to provide an output signal only in response to sensing a preselected rate of flow outward through said orifice; and

control means responsive to said flow sensing means for preventing operation of said fuel delivery means when said sensing means indicates less than said preselected flow through said orifice subsequent to initiation of operation of said blower means.

10. The heating apparatus of claim 9 further including means for sensing static pressure upstream of the orifice for providing a signal to said control means for further controlling operation of the fuel delivery means.

11. In a heating apparatus having means for generating hot gas, and a duct for conducting flow of the hot gas therethrough, the improvement comprising:

means defining a flow restricting orifice disposed within said duct, said orifice defining the smallest cross section through which said hot gas flows;

flow sensing means at the center of said flow restricting orifice to be in the portion of the gas flow through the orifice of least turbulence; and

control means responsive to said flow sensing means for preventing generation of hot gas by said heating apparatus when said sensing means senses less than a preselected flow through said orifice subsequent to initiation of flow of the hot gas therethrough.

12. The heating apparatus of claim 11 wherein said flow sensing means comprises a Pitot tube sensor opening adjacent said center of the flow restricting orifice.

13. The heating apparatus of claim 11 wherein said flow sensing means is disposed downstream of said center of the orifice.

14. The heating apparatus of claim 11 wherein said flow sensing means comprises a Pitot tube extending fully through said center of the orifice.

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